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Incentivising selective fishing under catch quotas: using an FCube modelling approach to evaluate management options for North Sea mixed fisheries

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Summary
Reforms of EU Common Fisheries Policy will make fundamental changes to European fisheries management, including a discard ban with catch quotas for regulated species and management to achieve MSY. We evaluate the impact of these changes on revenue of North Sea demersal finfish fleets and fish stocks. With no change in behaviour, revenue is reduced by a mean of 31% compared to current management in the first year, but partly recovers by year 3, as fishing mortality is reduced and stocks increase. There are large differences in revenue changes between fleets, varying from -99% to +36%, depending on whether the stock with the most limiting catch quota is a primary target and the rate at which it is caught relative to other stocks. Impacts will be greatest if catch quotas are set at current landings quotas, and reduce with an uplift to reflect current discarding levels. Large reductions in revenue create a strong incentive to avoid catching the limiting species, particularly if it is not a primary target. Selectivity changes that avoid 30% cod catch reduced the economic impact for some fleets in moving to catch quotas. Increased flexibility will therefore be important in maintaining the profitability of the fisheries.

Introduction
The reform of the European Union's (EU) Common Fisheries Policy (CFP; European Union, 2013) introduces a discard ban for regulated species combined with catch quotas. Starting from 2015 total catches rather than just landings will count against quota and there is a legally binding requirement to manage fisheries in a way that achieves maximum sustainable yield (MSY) by 2020. Full documentation of catches allows part of the quota currently set aside to account for discards to be added to landing quotas, but once the quota is exhausted fishers must halt any activities that risk the capture of the regulated species. Reducing unwanted catches in mixed fisheries will be required if fishers are to maximise income from available quota.

Pilot schemes have shown catch quotas create strong economic incentives for a change in fishing behaviour, such as avoidance of sub-legally sized fish and reduced targeting of quota species (Condie et al 2014). The strength of incentive may depend on how quota is distributed and current size and species composition of catches, so how catch quotas are implemented plays a significant role in determining any potential changes in fishing behaviour (Condie et al., 2014). Using Fcube (Fleet and Fisheries Forecast) (Ulrich *et al*., 2011) we evaluate the potential impact on stocks and fleets of different implementation protocols in the multi-stock, multi-fleet fishery of the North Sea and identify management options that would produce the strongest incentives for more selective fishing.

Materials and Methods
Using Fcube we estimated the potential level of effort that could be exerted by fleets in future years, based on fishing opportunities, catchability and relative effort share. The model is parameterised on data from the ICES WGMIXFISH group and Harvest Control Rules consistent with current management plans, or FMSY and fishing stops for a fleet when the first quota is reached. Potential changes in the catches of six stocks from the North Sea demersal fisheries are forecast with different catch quota implementation protocols are compared to the current single-species quota management. Protocols include i) catch quotas set in line with existing TACs (or total allowable landings, TALs); ii) in line with a 30% increase in existing TALs, or increased to account for iii) 75% or iv) 100% of discards. The potential effect of changes in fishers behaviour is simulated by fleets catching i) no under

Minimum Landing Size (MLS) fish, ii) no under MLS cod, and iii) a 30% reduction in cod catchability. Revenue generated from catches is estimated based on data collated by the ICES WGMIXFISH group and the STECF (Jardim *et al*, 2013). Catch under the legal MLS was estimated by species, nation and métier using STECF and survey data.

Results and Discussion

Results indicate that were catch quotas implemented without any behavioural change revenue from the six stocks modelled will reduce by a mean 31% in 2014, 25% in 2015 and 15% in 2016 (across all fleets, protocols) compared to current management. This is due to an under-utilisation of quotas other than cod (with cod being the choke stock for most fleets), with revenue increasing each year due to a rapidly increasing cod stock allowing more quota to be fished in future years. A three way analysis of variance shows that the effects of fleet (F=1479, p<0, df=34), protocol (F=1109, p<0, df=3) and year (F=829, p<0, df=2) explained 86% of the variance in the results, suggesting that the protocol and characteristics of the fleet are key factors determining revenue change during the transition to catch quotas. Unsurprisingly, the larger the proportion of catch previously discarded that is allocated to the fleets, the lesser the impact on reductions in revenue (Figure 1(a)), but impact fleets varied significantly (Figure 1(b) – from -99% to +36%). The largest reductions in revenue were for fleets that had to forego their target stock quota and the limiting stock was only a small proportion of revenue; fleets limited by their target stock could increase revenue from being able to land previously discarded >MLS fish. Selectivity improvements which avoid catching cod (Figure 1(c)) had a positive impact on revenue, indicating this will be the key challenge the fisheries face. Extending the work in *Condie et al* (2014) we looked at the implementation of the landings obligation across the multi-stock multi-fleet North Sea demersal fisheries. It shows the potential stock (and longer term fishery) benefits from reduced fishing mortalities moving to catch quotas, but highlights a varied economic impact on fleets in the transition; efforts should focus on ensuring maximum flexibility for fleets during this period, particularly to avoid non-target quota species becoming economic choke stocks in the fisheries.

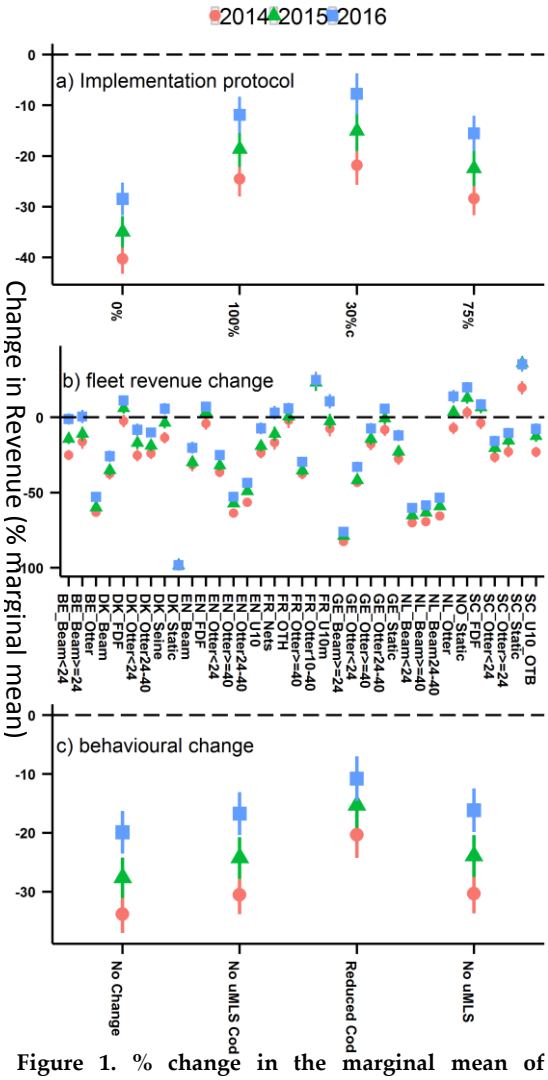

Figure 1. % change in the marginal mean of revenue from baseline across all factors, except year and; (a) implementation protocol, (b) fleets, (c) simulated behavioural change (lines indicate

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